Prepared for:
Dominion, Inc
Richmond, VA

Best Available Retrofit Technology (BART) Exemption Modeling Analysis – Yorktown Power Station Unit 3

ENSR Corporation
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1.0 Introduction

1.1 Objectives

The Regional Haze Rule requires Best Available Retrofit Technology (BART) for any BART-eligible source that ‘‘emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility” in any mandatory Class I federal area. Pursuant to federal regulations, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling demonstrating that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. In addition, the Environmental Protection Agency (EPA) has promulgated a rule allowing states subject to the Clean Air Interstate Rule (CAIR) to determine that CAIR satisfies the BART requirements for SO_2 and NOx for electric generating units (EGUs). The Virginia Department of Environmental Quality (DEQ) has determined that CAIR satisfies the BART requirements for SO_2 and NOx for EGUs. Therefore, this modeling report focuses on performing the BART modeling analysis for particulate matter (PM) only. The final BART rule at 70 FR 39160 notes that PM_{10} may be used as an indicator for PM in this step of the BART process and thus, PM_{10} was used for the exemption modeling.

Unit 3 at Yorktown Power Station (Yorktown), located in Yorktown, VA, is owned and operated by Dominion and has been identified as a BART-eligible source. The modeling procedures outlined in this report were used to determine whether the source is subject to BART requirements. The modeling procedures are consistent with the protocol letter submitted to DEQ on April 13, 2006 along with those outlined in the updated final VISTAS common protocol (dated December 22, 2005, revision 3 – July 18, 2006). The VISTAS common protocol is available at http://www.vistas-sesarm.org/BART/BARTModelingProtocol_rev3_18Jul2006.pdf.

The results of the refined CALPUFF modeling analysis demonstrates that PM_{10} emissions from Yorktown Unit 3 do not cause or contribute to regional haze in any Class I area. Thus, Yorktown Unit 3 is not “subject to BART” and is exempt from further analysis under the BART rule.

1.2 Location of Source vs. Relevant Class I Areas

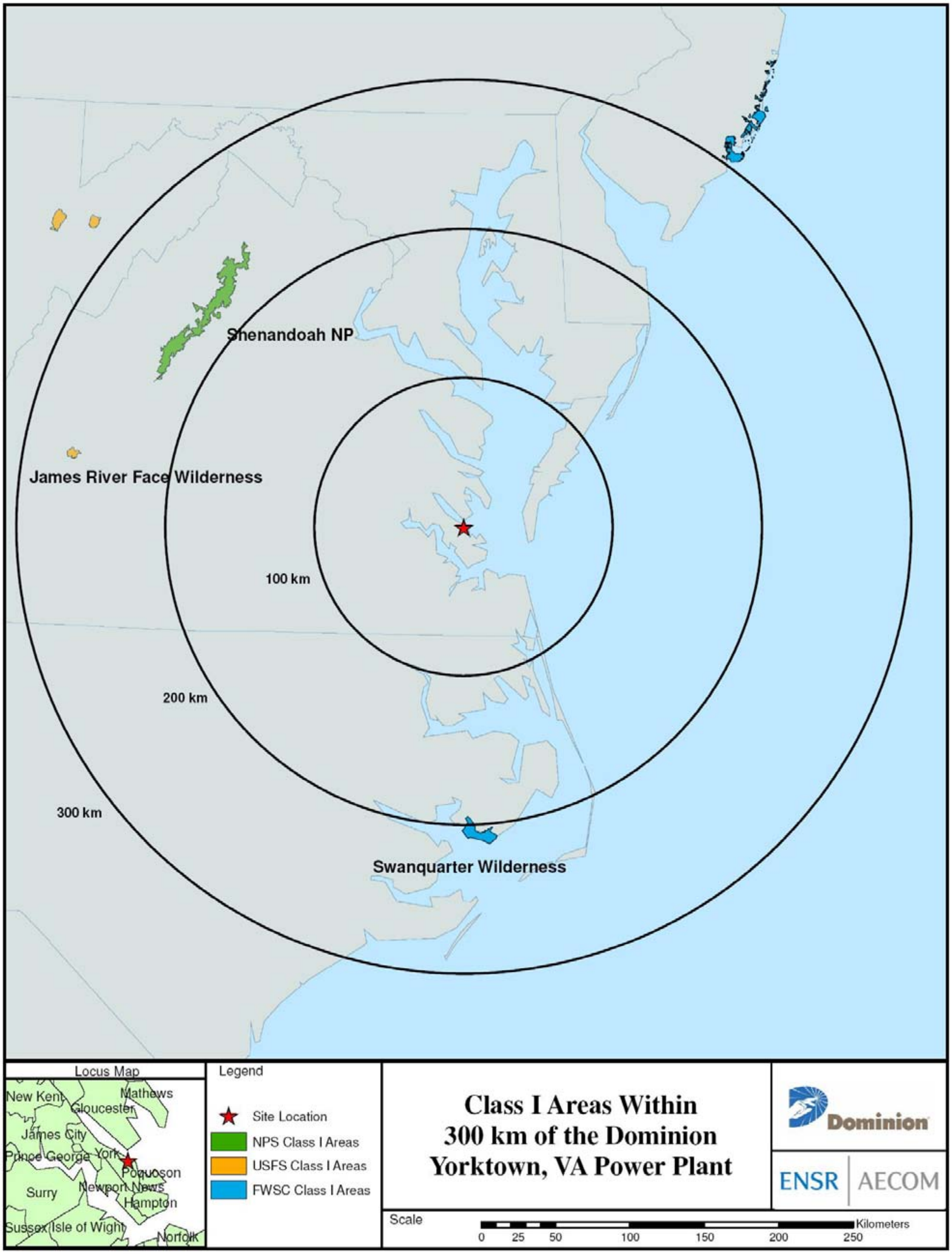
DEQ has determined that Unit 3 at Yorktown is BART-eligible for PM_{10}. Figure 1-1 shows a plot of Yorktown relative to nearby Class I Areas. There are three Class I areas within 300 km of the plant:

- Shenandoah National Park (~220 km),
- James River Face Wilderness (~260 km), and
- Swanquarter Wilderness (~200 km).

1.3 Organization of Report Document

Section 2 of this report describes the source emissions that were used as input to the BART exemption modeling. Section 3 describes the input data that was used for the modeling, including the modeling domain, terrain and land use, and meteorological data. Section 4 describes the air quality modeling procedures and Section 5 discusses the modeling results. Since all of the references cited are also included in the VISTAS common BART modeling protocol (Section 7 of that document), no additional references section is included in this document. Appendices A and B provide additional information on the baseline source emissions. Appendix C includes a printout of excerpts of CALPOST list files.

Figure 1-1 Location of Class I Areas in Relation to Yorktown



2.0 Source Description and Emissions Data

2.1 Unit-Specific Source Data

The emissions data used to assess the visibility impacts at the Class I areas within 300 km of Yorktown is discussed in this section. DEQ has indicated that CAIR will satisfy BART for EGUs for SO_2 and NO_X. Therefore, this BART exemption analysis focuses only on PM_{10}. Since various components of PM_{10} emissions have different visibility extinction efficiencies, the PM_{10} emissions are divided, or “speciated,” into several components (VISTAS common protocol Sections 4.3.3 and 4.4.2). The VISTAS protocol (Section 5) allows for the use of source-specific emissions and speciation factors or default values from AP-42. The PM_{10} emissions and speciation approach that were used for the modeling is indicated below.

Yorktown Unit 3 is a residual oil fired utility boiler with no PM emission controls. PM speciation was based on a stack test result for filterable PM emissions and a methodology developed by the National Park Service based on AP-42 as described in Appendix A.

- Total PM_{10} is comprised of filterable and condensable emissions.

- Baseline filterable PM_{10} emissions are based on a stack result showing filterable PM emissions at 0.0773 lb/MMBtu. This stack test is used with data from AP-42 indicating that 71% of filterable PM emissions are filterable PM_{10} emissions to calculate a filterable PM_{10} emission rate of 0.0549 lb/MMBtu. This filterable PM_{10} emission rate is used in the NPS spreadsheet with the heat input capacity to calculate the “maximum 24 hour average emission rate” as required by the VISTAS protocol.
- Filterable PM_{10} is subdivided by size category, using the NPS spreadsheet, consistent with the default approach from AP-42 indicating that 27.1% of filterable PM_{10} emissions is coarse (greater than 2.5 microns in size) and 72.9% is fine. Of the fine portion, 7.4% is elemental carbon and the remainder is inorganic fine particulates (soil).
- Condensable PM_{10} consists of inorganic and organic compounds. The inorganic portion is by default assumed to be H_2SO_4, although other non-sulfate inorganic condensables could be present. The organic portion is modeled as organic aerosols.
- Condensible PM_{10} emissions are calculated, using the NPS spreadsheet, consistent with AP-42. Total condensible PM10 emissions are 1.5 lb/1,000 gallon of oil burned. Inorganic condensible PM_{10} emissions are 85% of the total condensible PM_{10} emissions and organic condensible PM_{10} emissions are 15% of the total condensible PM_{10} emissions.

In practice, CALPUFF allows for the user to input certain components of PM_{10} as separate species and separate sizes, which will result in more accurate wet and dry deposition velocity results and also more accurate effects on light scattering. As noted above, the particle size distribution information is provided in AP-42 Table 1-1.6, and was used for the BART exemption modeling.

Table 2-1 provides a summary of the modeling emission parameters that were used in the BART exemption modeling, consistent with the source emissions data presented in Appendices A and B.

Table 2-1 Yorktown Modeling Emissions and Stack Parameters[1]

Case	Source / Unit	Location UTM (Zone 18 NAD-83)		Actual Stack Ht	Base Elev.	Flue Dia-meter	Gas Exit Vel.	Stack Gas Exit Temp.	Particle Speciation[2]							
		UTM East	UTM North						Filt. PM_{10}	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM10	H_2SO_4	Organic
		M	M	m	m	m	m/s	deg K	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr
Baseline	Unit 3	370.39	4119.5	149.05	3.05	6.858	33.5	415.9	459.3	124.5	334.7	310.0	24.8	83.3	70.8	12.5
Stack Basis Emissions Converted to g/sec									g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
Baseline	Unit 3	370.39	4119.5	149.05	3.05	6.858	33.5	415.9	57.86	15.69	42.17	39.05	3.12	10.49	8.92	1.57

[1] With Virginia being a CAIR-affected state, SO_2 and NO_X emissions are not BART-applicable for EGU sources.

[2] Elemental carbon (EC) and fine PM are a part of filterable PM_{10} and H_2SO_4 and organics are a part of condensable PM_{10}.

[3] Stack credit is equal to actual stack height since this stack is grandfathered.

3.0 Input Data to the CALPUFF Model

3.1 General Modeling Procedures

VISTAS has developed five sub-regional 4-km CALMET meteorological databases for three years (2001-2003). The sub-regional modeling domains are strategically designed to cover all potential BART eligible sources within VISTAS states and all PSD Class I areas within 300 km of those sources. The extents of the 4-km sub-regional domains are shown in Figure 4-4 of the VISTAS common BART modeling protocol. The BART exemption modeling for Yorktown was conducted with 4-km CALMET resolution from sub-domain #5. As shown in Figure 3-1, sub-domain 5 covers all of Virginia and the Class I areas needed for the exemption modeling analysis.

A computational grid was developed to be a subset of the sub-domain 5 meteorological grid. The computational grid was designed to include the three Class I areas and Yorktown along with a 50-km buffer. The additional 50-km distance allows for a sufficient buffer to enable puffs to recirculate. The computational grid extent in relation to the sub-domain #5 meteorological grid is shown in Figure 3-1.

USGS 90-meter Digital Elevation Model (DEM) files were used by VISTAS to generate the terrain data at 4-km resolution for input to the 4-km sub-regional CALMET run. Likewise, USGS 90-meter Composite Theme Grid (CTG) files were used by VISTAS to generate the land use data at 4-km resolution for input to the 4-km sub-regional CALMET run.

Three years of MM5 data (2001-2003) were used by VISTAS to generate the 4-km sub-regional meteorological datasets. See Sections 4.3.2 and 4.4.2 in the VISTAS common BART modeling protocol for more detail on the incorporation of MM5 data and surface observations into the CALMET wind field.

All exemption modeling was conducted using the 4-km CALMET data in sub-domain #5 along with a truncated computational grid.

3.2 Air Quality Database (Background Ozone and Ammonia)

Hourly measurements of ozone from all non-urban monitors within and just outside the computational grid, as generated by VISTAS (available at: http://www.src.com/verio/download/sample_files.htm), was used as input to CALPUFF. The model default of 80 ppb was used for the background ozone concentration in the instance when all hourly data was missing for each station. As for the background ammonia value, VISTAS has recommended that a constant background value of 0.5 ppb should be used rather than using ammonia data derived from CMAQ model output. The exemption modeling conducted for the Yorktown follows these recommendations of VISTAS and uses 0.5 ppb as a constant ammonia background value.

3.3 Natural Conditions and Monthly f(RH) at Class I Areas

There are three Class I areas within 300 km of Yorktown (as noted in Figure 1-1). For each of the Class I areas, natural background conditions must be established in order to determine a change in natural conditions related to a source's emissions. For the BART exemption modeling, natural background light extinction corresponding to the annual average (EPA 2003) values were used as an initial estimate. This is consistent with guidance received from DEQ that allows for the use of the annual average background.

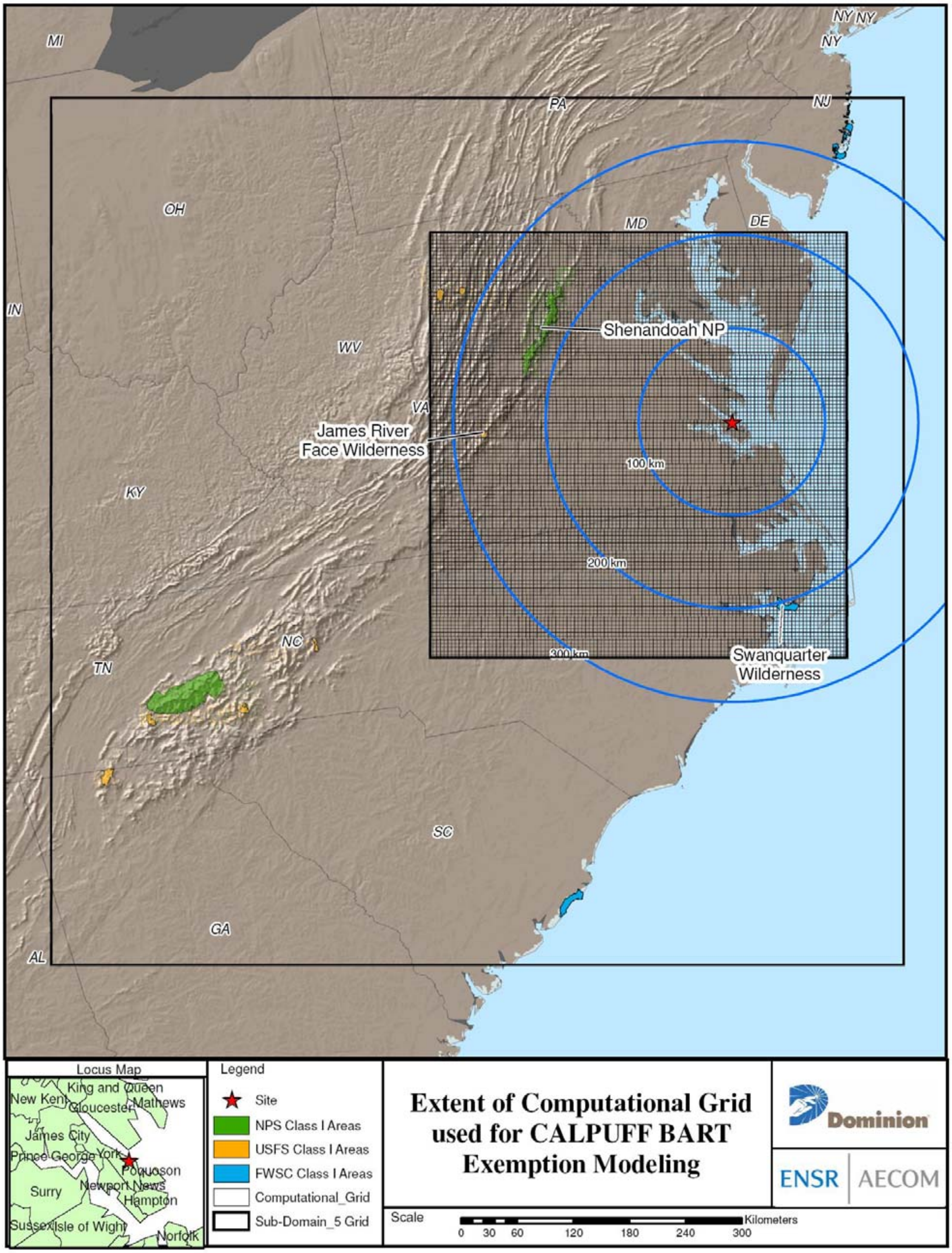
To determine the input to CALPUFF, it is first necessary to convert the deciviews to extinction using the equation:

Extinction (Mm^{-1}) = 10 exp(deciviews/10).

For example, the EPA guidance document indicates for Swanquarter Wilderness Area that the deciview value for the annual average is 7.38. This is equivalent to an extinction of 20.92 inverse megameters (Mm^{-1}).

This extinction includes the default 10 Mm^{-1} for Rayleigh scattering. The remaining extinction is due to naturally occurring particles, and should be held constant for the entire year's simulation. Therefore, the data provided to CALPOST for Swanquarter was the total annual average natural background extinction minus 10 (expressed in Mm^{-1}), or 10.92. This was most easily input as fine soil concentrations (10.92 $\mu g/m^3$) in CALPOST, since the extinction efficiency of soil (PM-fine) is 1.0 and there is no f(RH) component. The concentration entries for all other particle constituents were set to zero, and the fine soil concentration was kept the same for each month of the year. The monthly values of f(RH) that CALPOST needs were taken from "Guidance for Tracking Progress Under the Regional Haze Rule" (EPA, 2003) Appendix A, Table A-3. These procedures were consistent with the "base case" VISTAS approach that did not account for site-specific changes to background due to naturally-occurring sea salt and near-sea-level Rayleigh scattering.

Figure 3-1 Extent of Computational Grid



4.0 Air Quality Modeling Procedures

This section provides a summary of the modeling procedures outlined in the VISTAS protocol that were used for the refined CALPUFF BART exemption modeling conducted for Yorktown Unit 3.

4.1 Model Selection and Features

As recommended in the VISTAS protocol, this exemption modeling uses the BART-specific versions of CALMET and CALPUFF posted at http://www.src.com/verio/download/download.htm#VISTAS_VERSION. These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They are maintained on TRC's website for public access. This release includes CALMET, CALPUFF, CALPOST, CALSUM, and POSTUTIL as well as CALVIEW.

The major features of the CALPUFF modeling system, including those of CALMET and the post-processors (CALPOST and POSTUTIL), are referenced in Section 3 of the VISTAS protocol.

4.2 Modeling Domain and Receptors

The Yorktown runs used the 4-km CALMET data in sub-domain #5 that was supplied by VISTAS, as discussed above. A computational grid was developed to be a subset of the sub-domain #5 meteorological grid. The computational grid was designed to include the three Class I areas and Yorktown along with a 50-km buffer. The additional 50-km distance allowed for a sufficient buffer to enable puffs to recirculate. The computational grid extent in relation to the sub-domain #5 meteorological grid is shown in Figure 3-1.

The receptors used for each of the Class I areas are based on the NPS database of Class I receptors, as recommended by the VISTAS common protocol (Section 4.3.3).

4.3 Technical Options Used in the Modeling

CALMET modeling for the VISTAS 4-km sub-domains was pre-determined by the VISTAS contractor, and, therefore, we assume that VISTAS approves of the manner in which CALMET has been run for the sub-domain data that they provide.

For CALPUFF model options, Yorktown followed the VISTAS common BART modeling protocol (Section 4.4.1), which states that we should use IWAQM (EPA, 1998) guidance. The VISTAS protocol also notes that building downwash effects are not required to be included unless the state directs the source to include these effects. Yorktown did not include building downwash effects in the CALPUFF modeling.

The POSTUTIL utility program (described in VISTAS common protocol Section 4.4.2) was used to repartition HNO_3 and NO_3 concentrations using the constant ammonia background value of 0.5 ppb.

4.4 Light Extinction and Haze Impact Calculations

The CALPOST postprocessor was used as prescribed in the VISTAS protocol for the calculation of light extinction due to the impact from the modeled source's primary and secondary particulate matter. The assessment of visibility impacts at the Class I areas used CALPOST Method 6 (as noted in the VISTAS common protocol Section 4.3.2). Each hour's source-caused extinction is calculated by first using the hygroscopic components of the source-caused concentrations due to ammonium sulfate, and monthly Class I area-specific f(RH) values (see Table 4-1). The contribution to the total source-caused extinction from ammonium sulfate is then added to the other, non-hygroscopic components of the particulate concentration (from coarse and fine soil, secondary organic aerosols, and from elemental carbon) to yield the total hourly source-caused extinction.

The formula that was used to calculate the extinction is the existing (not the November 2005 revised) IMPROVE/EPA formula, which is applied to determine a change in light extinction due to increases in the particulate matter concentrations. Using the notation of CALPOST, the formula is the following:

$$b_{ext} = 3\ f(RH)\ [(NH_4)2SO_4] + 3\ f(RH)\ [\ NH_4NO_3] + 4[OC] + 1[Soil] + 0.6[Coarse\ Mass] + 10[EC] + b_{Ray}$$

The concentrations, in square brackets, are in µg/m^3 and b_{ext} is in units of Mm^{-1}. The Rayleigh scattering term (b_{Ray}) has a default value of 10 Mm^{-1}, as recommended in EPA guidance for tracking reasonable progress (EPA, 2003a).

In this exemption modeling analysis for Yorktown Unit 5, we used site-specific monthly f(RH) values and annual average background concentrations from Appendices A and B of the "Guidance for Estimating Natural Visibility Under the Regional Haze Rule" EPA 2003. Table 4-1 summarizes the monthly f(RH) and annual average concentrations used as input to CALPOST.

The BART rule significance threshold for the contribution to visibility impairment is 0.5 deciviews. The VISTAS protocol (Section 4.3.2) indicates that with the use of the 4-km sub-regional CALMET database, a source does not cause or contribute to visibility impairment if the 98th percentile (or 8th highest) day's change in extinction from natural conditions does not exceed 0.5 deciviews for any of the modeled years. As an added check, the 22nd highest prediction over the three years modeled should also not exceed 0.5 deciviews for a source to be exempted from a BART determination.

Figure 4-1 of the VISTAS common BART modeling protocol presents a flow chart showing the components of that modeling protocol for the analysis to determine whether a source is subject to BART. It should be noted that the modeling for Yorktown focused on sub-regional fine-scale modeling as depicted in the lower half of the figure.

The exemption modeling results for the BART-eligible units at Yorktown are presented in Section 5.

Table 4-1 Annual Average Background and Monthly f(RH) used in CALPOST

Class I Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly f(RH)												
Shenandoah NP	3.1	2.8	2.8	2.5	3.1	3.4	3.5	3.9	3.9	3.2	3.0	3.4
James River Face W	2.8	2.6	2.7	2.4	3.0	3.3	3.4	3.7	3.6	3.2	2.8	3.2
Swanquarter NWR	2.9	2.7	2.6	2.5	2.9	3.2	3.4	3.5	3.4	3.1	2.8	3.1
Annual Average Background (1) (Mm^{-1})												
Shenandoah NP	10.98 (same for all months)											
James River Face W	10.96 (same for all months)											
Swanquarter NWR	10.92 (same for all months)											

(1) Value is adjusted to remove the default Rayleigh scattering coefficient of 10 Mm^{-1}.

5.0 Presentation of Modeling Results

The exemption modeling results for Unit 3 at Yorktown are provided in Table 5-1. Appendix B lists delta-deciview results for the top 20 days for each year modeled at each Class I area. The table indicates that both the highest and the 8th highest day's impacts for each year are below 0.5 dv. These results demonstrate that Yorktown Unit 3 PM_{10} emissions do not cause or contribute to regional haze in any Class I area within 300 km of the source. Therefore, the Yorktown Unit 3 is not "subject to BART" and no further BART analysis is required.

Table 5-1 Summary of Results – Yorktown Refined BART Exemption Modeling

Class I Area	Distance (km) from source to Class I area boundary	# of days with impact > 0.5 dv in Class I				Max. 24-hr impact over 3-yr period (dv)	Max 8th highest impact over 3-yr period (dv)
		2001	2002	2003	3-Year Total		
James River Face, VA	~ 262 km	0	0	0	0	0.144	0.034
Shenandoah, VA	~ 220 km	0	0	0	0	0.188	0.065
Swanquarter, NC	~ 200 km	0	0	0	0	0.165	0.105

Appendix A

Basis for Source-Specific PM_{10} Speciation and Sulfuric Acid Emissions for BART Baseline Case

PM speciation was based on a stack test result for filterable PM emissions and a methodology developed by the National Park Service based on AP-42 . Details on the NPS methodology follow the table on Page A-3 below.

Yorktown 3

Controlled PM10 Speciation from AP-42 Tables 1.3-2 & 1.3-4 [(a)]
Uncontrolled Utility Residual Oil Boiler

Fuel oil is **6** oil with a sulfur content of **1.30** %S; therefore, A = **1.4018 BASED ON STACK TEST RESULT** f(RH) = 1

Heating value is **150,701** Btu/Gal and the maximum 24-hour average actual heat input is **8,368** MMBtu/hr

	Uncontrolled PM10 Emissions (**Bold** Values from Tables 1.3-2 and 1.3-4.)															
Boiler Type	Total PM10 (lb/mGal)	Filterable (lb/mGal)	Coarse (lb/mGal)	Ext. Coef.	Fine (lb/mGal)	Fine Soil (lb/mGal)	Ext. Coef.	Fine EC (lb/mGal)	Ext. Coef.	Condensible (lb/mGal)	CPM IOR (lb/mGal)	Particle Type	Particle Ext.Coef.	CPM OR (lb/mGal)	Particle Type	Particle Ext.Coef.
Utility	9.77	**8.27**	2.24	0.6	**6.03**	5.58	1	0.45	10	**1.5**	1.28	SO4	3*f(RH)	0.23	SOA	4

	Uncontrolled PM10 Emissions															
Boiler Type	Total PM10 (% of Total)	Filterable (% of Total)	Coarse (% of Total)	Ext. Coef.	Fine (% of Total)	Fine Soil (% of Total)	Ext. Coef.	Fine EC (% of Total)	Ext. Coef.	Condensible (% of Total)	CPM IOR (% of Total)	Particle Type	Particle Ext.Coef.	CPM OR (% of Total)	Particle Type	Particle Ext.Coef.
Utility	100%	84.6%	23.0%	0.6	61.7%	57.1%	1	4.6%	10	15.4%	13.0%	SO4	3*f(RH)	2.3%	SOA	4

	Uncontrolled PM10 Emissions															
Boiler Type	Total PM10 (lb/mmBtu)	Filterable (lb/mmBtu)	Coarse (lb/mmBtu)	Ext. Coef.	Fine (lb/mmBtu)	Fine Soil (lb/mmBtu)	Ext. Coef.	Fine EC (lb/mmBtu)	Ext. Coef.	Condensible (lb/mmBtu)	CPM IOR (lb/mmBtu)	Particle Type	Particle Ext.Coef.	CPM OR (lb/mmBtu)	Particle Type	Particle Ext.Coef.
Utility	0.06	0.05	0.01	0.6	0.04	0.04	1	0.003	10	0.01	0.01	SO4	3*f(RH)	0.001	SOA	4

If you are given Total PM10 emissions in lb/hr:

	Uncontrolled PM10 Emissions (**Bold** Value is **Input** by user.)															
Boiler Type	Total PM10 (lb/hr)	Filterable (lb/hr)	Coarse (lb/hr)	Ext. Coef.	Fine (lb/hr)	Fine Soil (lb/hr)	Ext. Coef.	Fine EC (lb/hr)	Ext. Coef.	Condensible (lb/hr)	CPM IOR (lb/hr)	Particle Type	Particle Ext.Coef.	CPM OR (lb/hr)	Particle Type	Particle Ext.Coef.
Utility	**542.6**	459.3	124.5	0.6	334.7	310.0	1	24.8	10	83.3	70.8	SO4	3	12.5	SOA	4
		Weighted Extinction		74.7			310.0		247.7				212.4			50.0

If you are given Total PM10 emissions in lb/mmBtu:

	Uncontrolled PM10 Emissions (**Bold** Value is **Input** by user.)															
Boiler Type	Total PM10 (lb/mmBtu)	Filterable (lb/mmBtu)	Coarse (lb/mmBtu)	Ext. Coef.	Fine (lb/mmBtu)	Fine Soil (lb/mmBtu)	Ext. Coef.	Fine EC (lb/mmBtu)	Ext. Coef.	Condensible (lb/mmBtu)	CPM IOR (lb/mmBtu)	Particle Type	Particle Ext.Coef.	CPM OR (lb/mmBtu)	Particle Type	Particle Ext.Coef.
Utility	**0.065**	0.0549	0.015	0.6	0.040	0.037	1	0.003	10	0.010	0.008	SO4	3	0.001	SOA	4

	Uncontrolled PM10 Emissions (**Bold** values from Table 1.3-2 and from Table 6 of EPA's January 2002 DRAFT "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon.")															
Boiler Type	Total PM10 (% of Total)	Filterable (% of Total)	Coarse % of Filterable	Ext. Coef.	Fine (% of Filterable)	Fine Soil (% of Filterable)	Ext. 1	Fine EC (% of Filterable)	Ext. Coef.	Condensible (% of Total)	CPM IOR (% of Condensible)	Particle Type	Particle Ext.Coef.	CPM OR (% of Condensible)	Particle Type	Particle Ext.Coef.
Utility	100%	84.6%	27.1%	0.6	72.9%	67.5%	1	5.4%	10	15.4%	**85%**	SO4	3	**15%**	SOA	4
						(% of Fine)	Coef.	(% of Fine)	Coef.							
						92.6%	1	**7.4%**	10							

If you are given Filterable PM10 emissions in lb/hr:

	Uncontrolled PM10 Emissions (**Bold** Value is **Input** by user.)															
Boiler Type	Total PM10 (lb/hr)	Filterable (lb/hr)	Coarse (lb/hr)	Ext. Coef.	Fine (lb/hr)	Fine Soil (lb/hr)	Ext. Coef.	Fine EC (lb/hr)	Ext. Coef.	Condensible (lb/hr)	CPM IOR (lb/hr)	Particle Type	Particle Ext.Coef.	CPM OR (lb/hr)	Particle Type	Particle Ext.Coef.
Utility	542.6	**459.3**	124.5	0.6	334.7	310.0	1	24.8	10	83.3	70.8	SO4	3	12.5	SOA	4

If you are given Filterable PM10 emissions in lb/mmBtu:

	Uncontrolled PM10 Emissions (**Bold** Value is **Input** by user.)															
Boiler Type	Total PM10 (lb/mmBtu)	Filterable (lb/mmBtu)	Coarse (lb/mmBtu)	Ext. Coef.	Fine (lb/mmBtu)	Fine Soil (lb/mmBtu)	Ext. Coef.	Fine EC (lb/mmBtu)	Ext. Coef.	Condensible (lb/mmBtu)	CPM IOR (lb/mmBtu)	Particle Type	Particle Ext.Coef.	CPM OR (lb/mmBtu)	Particle Type	Particle Ext.Coef.
Utility	0.065	**0.0549**	0.015	0.6	0.040	0.037	1	0.003	10	0.010	0.008	SO4	3	0.001	SOA	4

PM10 Results		Model Input Data			
Coarse	23.0%	**Coarse**	**124.55**	**lb/hr**	
Fine Soil	57.1%	**Fine Soil**	**309.96**	**lb/hr**	
Fine EC	4.6%	**Fine EC**	**24.77**	**lb/hr**	
CPM IOR	13.0%	**CPM IOR**	**70.80**	**lb/hr**	h2so4
CPM OR	2.3%	**CPM OR**	**12.49**	**lb/hr**	soa
Total	100.0%	**Total**	**542.57**	**lb/hr**	
		so4	69.35		

(a) Dominion input data are shown in bold red font.

Yorktown - PM10 Speciation based on AP-42 emission factors.xls Yorktown 3

Particulate Matter Speciation

Oil-Fired Boiler PM_{10}

Highlights
Uncontrolled Industrial Oil Boiler Example (Excel XP Format, 55 kb, updated 03/2006)
Uncontrolled Utility Oil Boiler Example (Excel XP Format, 55 kb, updated 03/2006)
Industrial Oil Boiler MultiCyclone Example (Excel XP Format, 55 kb, updated 03/2006)
Utility Oil Boiler ESP Example (Excel XP Format, 55 kb, updated 03/2006)
Utility Oil Boiler Scrubber Example (Excel XP Format, 55 kb, updated 03/2006)

Recommendations for modeling the particulate matter (PM_{10}) speciation for three types of Utility Oil-fired boilers (Uncontrolled, with Scrubber, and with ESP) and two types of Industrial Oil-fired boilers (Uncontrolled, and Multicyclone), are contained in the Excel workbooks available in the Highlights box. Instructions for using the workbooks are available below.

The derivation of these values is based on data from AP-42, Section 1.3 (Fuel Oil Combustion), as described below. Any individual source may deviate from these recommendations with the conditional approval of the Federal Land Manager (FLM) and the Regulatory Authority. Applicants seeking approval of an alternate speciation profile should submit stack testing data or other documentation supporting use of a different profile for the source in question. Where a different speciation profile is approved, the FLMs may request that the Regulatory Authority include emissions testing requirements in the source's permit to confirm the validity of the alternate profile.

The filterable PM_{10} represents the emissions captured using the Method 5 "front-half" filter and the condensable PM_{10} represents the emissions captured using the Method 202 "back half" method. Filterable emissions consist of mostly fine and coarse ash from combustion, plus some unburned carbon from the fuel. In modern boiler systems, the fuel combustion should be nearly complete, so it can be assumed that most of the filterable PM_{10} will be inorganic flyash material.

Filterable PM_{10} mass is speciated as follows. Filterable PM_{10} size speciation data are given in AP-42 Tables 1.3-4 and 13-5. Filterable mass sized 2.5 microns or less fall into the fine PM_{10} category when calculating light extinction with the CALPUFF system. Although most of the fine PM_{10} has a light extinction coefficient (B_{ext}) of 1.0, the FLMs will assume that a nominal 7.4% of the fine PM_{10} emissions is unburned elemental carbon contained in the flyash[1]. The remainder of the filterable PM_{10} is coarse PM_{10} which has a light extinction coefficient (B_{ext}) of 0.6.

For the condensable PM_{10} emissions, AP-42 Table 1.3-2 separates the condensable PM_{10} into "inorganic" and "organic", with 85% of the condensable PM_{10} listed as inorganic and 15% listed as organic for residual oil-fired boilers. The organic/inorganic breakout is believed to be based on the fraction of the condensable PM collected in the "solvent extractable" portion of Method 202.

It is assumed that the "organic" condensable PM_{10} (CPM OR) is comprised of

Secondary Organic Aerosols (SOA) with a light extinction coefficient of 4.0. The "inorganic" condensable PM_{10} (CPM IOR) is assumed comprised of sulfate (SO_4) with a light extinction coefficient of 3.0 * f (RH), which accounts for the hygroscopic growth of sulfate aerosol in the presence of water vapor. This growth in particle size increases the light-scattering abilities of the sulfate aerosols[2].

The recommended PM_{10} speciation should be applied to the PM_{10} emission rate estimated for the source. Ideally, both the "filterable" and "condensable" PM_{10} emissions would be provided. Also, for modeling of visibility impacts and 24-hour PM_{10} NAAQS and PSD increments, the PM_{10} emission rate input to CALPUFF should not represent a compliance averaging time of longer than 24-hours.

Using the Workbooks

PLEASE NOTE: These workbooks are not "recyclable". Depending upon how you use them, certain links may be broken that would be essential for a different application. Download the workbook, rename the workbook before beginning any calculations, and use a new workbook for each application.

It should also be noted that these workbooks were developed primarily for application to existing boilers for which there may be no explicit limits on pollutants such as H_2SO_4. However, for new boilers for which information may be available on multiple PM_{10} constituents, the workbooks can be modified to incorporate that additional data.

Select the Excel workbook that most closely resembles the boiler in question. The **bold** values in the magenta cells in rows five and six of the spreadsheets are dummy values for fuel quality (oil grade, heating value, % sulfur), heat input rate (mmBtu/hr), and humidity (f(RH)); the user should substitute actual values for fuel quality (and heat input rate if emissions are to be input in lb/mmBtu). **Because oil-fired boilers without FGDs are very sensitive to fuel grade and sulfur content, care should be taken to enter the correct values for these units**. (You can ignore the f(RH) value which is included to test the effect of humidity on relative light extinction of the various species.) Except as indicated, the **bold** values in the body of the spreadsheets represent data that were entered directly and originated in either AP-42 Table 1.3-2, 1.3-4, and 1.3-5, or, in the case of the "7.4% of Fines" value for elemental carbon, from Table 6 of EPA's January 2002 **DRAFT** "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon". **Unless entering "custom" values, do not change any value in a cell that is not both bold and colored magenta, orange, or yellow**.

Based upon the emissions data available (total or filterable PM_{10} in lb/hr or lb/mmBtu), enter the emission rate into the appropriate (orange or yellow) cell with a corresponding dummy value. Corresponding emission rates for filterables and condensables will show up in the green cells, and **emission rates for each species of condensables will appear in the blue cells–use these values. All condensable PM_{10} is considered to be submicron**.

In order to separate filterable PM_{10} emissions by size, the AP-42 Table 1.3-2, 1.3-4, and 1.3-5 size fractions for the appropriate boiler and controls were used. The resulting charts show filterable PM_{10} emissions in lb/hr for size ranges modeled by CALPUFF. Match the proper species with the correct size range. The assumption is made that **coarse PM_{10} is between 2.5 and 10 micron, and the corresponding emission rates are shown in the blue cells in the "PM Size" table. It is assumed that elemental carbon represents a small percentage of the fine PM_{10} and is all in the smallest CALPUFF size range (magenta cells). The remaining fine soil was assigned to the size range below 2.5 micron, and the results are shown in the blue cells (in g/sec). Please note that the smallest CALPUFF size range (magenta cells) has been split to show entries for fine soil and elemental carbon**.

Neither the filterable PM_{10} speciation spreadsheet nor its associated charts will work unless the correct value is calculated for total filterable PM_{10} emissions (in lb/hr). There are several ways to do this, depending upon the type of emissions data initially input:

- If you enter Total PM_{10} in lb/hr (into orange cell C28), everything is calculated automatically for you.
- If you enter Total PM_{10} in lb/mmBtu (into orange cell C35), you need to make sure that you have also entered the production rate into (magenta) cell I6; then, everything is calculated automatically for you.
- If you enter Filterable PM_{10} in lb/hr (into yellow cell E47), the spreadsheet will calculate Total PM_{10} (in lb/hr) in (green) cell C47. Transfer that value to (orange) cell C28, and everything is calculated automatically for you.
- If you enter Filterable PM_{10} in lb/mmBtu (into yellow cell E53), the spreadsheet will calculate Total PM_{10} (in green cell C46) in lb/mmBtu. Transfer that value to (orange) cell C35, and everything is calculated automatically for you, provided that you have entered the production rate into (magenta) cell I6.

Or, you can enter the Filterable PM_{10} emission rate (in lb/hr) directly into (yellow) cell E26 of the "PM (Size)" table.

If you have questions, comments, or suggestions, please contact Don Shepherd at the National Park Service, Air Resources Division in Denver at 303-969-2075 or contact us through the Webmaster link at the bottom of the page.

[1] Table 6 of EPA's January 2002 DRAFT "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon".

[2] The values in row 29 of the tables result from an experiment in which we were trying to understand the effect of coal quality and f(RH) on the overall extinction from a given PM speciation profile.

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Appendix B

CALPOST List Files for Shenandoah, James River Face, and Swanquarter

Ranked Daily Visibility Change for Shenandoah (Top 20 Days for Each Year)

								% of Modeled Extinction by Species						
YEAR	**DAY**	**HR**	**REC**	**DV(Total)**	**DV(BKG)**	**DELTA DV**	**f(RH)**	**%_SO4**	**%_NO3**	**%_OC**	**%_EC**	**%_PMC**	**%_PMF**	**Ranking**
2001	141	0	55	7.52	7.41	0.11	3.1	58.25	0	3.28	16.27	1.84	20.36	1
2001	178	0	55	7.505	7.41	0.096	3.4	59.92	0	3.08	15.26	2.65	19.1	2
2001	138	0	60	7.502	7.41	0.092	3.1	57.58	0	3.24	16.08	2.98	20.12	3
2001	253	0	336	7.496	7.41	0.086	3.9	63.52	0	2.84	14.1	1.89	17.65	4
2001	179	0	340	7.493	7.41	0.084	3.4	60.49	0	3.11	15.4	1.72	19.28	5
2001	305	0	53	7.49	7.41	0.08	3.2	58.15	0	3.17	15.74	3.25	19.69	6
2001	142	0	55	7.476	7.41	0.066	3.1	57.78	0	3.26	16.14	2.63	20.19	7
2001	210	0	53	7.475	7.41	0.065	3.5	60.52	0	3.02	14.97	2.75	18.74	8
2001	343	0	53	7.471	7.41	0.061	3.1	58.19	0	3.28	16.25	1.95	20.34	9
2001	347	0	141	7.468	7.41	0.058	3.1	56.66	0	3.19	15.83	4.52	19.8	10
2001	102	0	182	7.468	7.41	0.058	2.5	52.63	0	3.68	18.23	2.66	22.81	11
2001	247	0	55	7.456	7.41	0.046	3.9	63.8	0	2.86	14.16	1.46	17.72	12
2001	205	0	69	7.452	7.41	0.042	3.5	61.22	0	3.05	15.15	1.63	18.95	13
2001	129	0	310	7.449	7.41	0.039	3.1	58.61	0	3.3	16.37	1.23	20.49	14
2001	204	0	53	7.447	7.41	0.037	3.5	61.14	0	3.05	15.13	1.76	18.93	15
2001	19	0	310	7.447	7.41	0.037	3.1	56.76	0	3.2	15.85	4.36	19.84	16
2001	215	0	53	7.443	7.41	0.034	3.9	63.6	0	2.85	14.12	1.76	17.67	17
2001	72	0	336	7.444	7.41	0.034	2.8	55.89	0	3.49	17.28	1.71	21.63	18
2001	98	0	310	7.443	7.41	0.033	2.5	53.49	0	3.74	18.53	1.06	23.18	19
2001	44	0	55	7.44	7.41	0.031	2.8	55.49	0	3.46	17.16	2.42	21.47	20
2002	103	0	53	7.554	7.41	0.144	2.5	52.03	0	3.63	18.02	3.76	22.55	1
2002	42	0	343	7.544	7.41	0.134	2.8	55.65	0	3.47	17.21	2.13	21.54	2
2002	284	0	157	7.511	7.41	0.101	3.2	58.42	0	3.19	15.81	2.81	19.78	3
2002	283	0	53	7.487	7.41	0.078	3.2	58.6	0	3.2	15.86	2.51	19.84	4
2002	172	0	182	7.474	7.41	0.064	3.4	59.64	0	3.06	15.19	3.1	19.01	5
2002	235	0	340	7.472	7.41	0.062	3.9	64.21	0	2.88	14.26	0.82	17.84	6
2002	174	0	53	7.47	7.41	0.06	3.4	59.92	0	3.08	15.26	2.65	19.09	7
2002	80	0	310	7.466	7.41	0.056	2.8	54.28	0	3.39	16.79	4.54	21.01	8
2002	86	0	114	7.465	7.41	0.055	2.8	55.62	0	3.47	17.2	2.19	21.52	9
2002	130	0	336	7.463	7.41	0.053	3.1	57.93	0	3.26	16.18	2.37	20.25	10
2002	62	0	148	7.458	7.41	0.048	2.8	55.37	0	3.45	17.12	2.63	21.43	11
2002	234	0	182	7.456	7.41	0.046	3.9	64.17	0	2.87	14.25	0.88	17.83	12
2002	278	0	336	7.452	7.41	0.042	3.2	59.14	0	3.23	16	1.61	20.03	13
2002	274	0	182	7.45	7.41	0.04	3.9	63.82	0	2.86	14.17	1.43	17.73	14
2002	146	0	310	7.449	7.41	0.039	3.1	58.7	0	3.31	16.4	1.08	20.52	15
2002	195	0	227	7.446	7.41	0.037	3.5	61.35	0	3.06	15.18	1.42	18.99	16
2002	175	0	227	7.447	7.41	0.037	3.4	60.56	0	3.11	15.42	1.61	19.3	17
2002	252	0	53	7.445	7.41	0.036	3.9	62.99	0	2.82	13.99	2.7	17.5	18
2002	151	0	343	7.443	7.41	0.033	3.1	58.73	0	3.31	16.4	1.04	20.53	19
2002	41	0	60	7.442	7.41	0.032	2.8	56.18	0	3.5	17.37	1.21	21.74	20
2003	88	0	219	7.598	7.41	0.188	2.8	54.69	0	3.41	16.91	3.82	21.16	1
2003	266	0	219	7.596	7.41	0.186	3.9	62.39	0	2.79	13.85	3.64	17.33	2
2003	323	0	128	7.528	7.41	0.118	3	56.65	0	3.3	16.35	3.24	20.46	3
2003	328	0	336	7.513	7.41	0.103	3	57.4	0	3.34	16.57	1.96	20.73	4
2003	345	0	336	7.507	7.41	0.097	3.1	57.19	0	3.22	15.97	3.62	19.99	5
2003	71	0	157	7.502	7.41	0.092	2.8	54.51	0	3.4	16.86	4.14	21.09	6
2003	283	0	226	7.477	7.41	0.067	3.2	58.01	0	3.17	15.7	3.49	19.64	7
2003	38	0	227	7.466	7.41	0.056	2.8	56.09	0	3.5	17.34	1.37	21.7	8
2003	281	0	310	7.464	7.41	0.054	3.2	58.68	0	3.2	15.88	2.37	19.87	9
2003	136	0	350	7.463	7.41	0.053	3.1	57.95	0	3.26	16.19	2.35	20.25	10
2003	339	0	53	7.447	7.41	0.037	3.1	56.95	0	3.21	15.91	4.03	19.91	11
2003	87	0	53	7.446	7.41	0.036	2.8	56.2	0	3.51	17.38	1.17	21.75	12
2003	299	0	336	7.439	7.41	0.029	3.2	57.92	0	3.16	15.67	3.65	19.61	13
2003	75	0	182	7.439	7.41	0.029	2.8	56.18	0	3.5	17.37	1.22	21.74	14
2003	126	0	55	7.438	7.41	0.028	3.1	58.45	0	3.29	16.33	1.52	20.43	15
2003	233	0	182	7.437	7.41	0.027	3.9	63.53	0	2.85	14.11	1.87	17.65	16
2003	147	0	100	7.437	7.41	0.027	3.1	58.41	0	3.29	16.31	1.58	20.41	17
2003	257	0	55	7.436	7.41	0.026	3.9	62.93	0	2.82	13.97	2.8	17.48	18
2003	4	0	53	7.434	7.41	0.024	3.1	58.67	0	3.31	16.39	1.13	20.51	19
2003	117	0	349	7.43	7.41	0.021	2.5	51.94	0	3.63	17.99	3.94	22.51	20

Ranked Daily Visibility Change for James River Face (Top 20 Days for Each Year)

								% of Modeled Extinction by Species						
YEAR	**DAY**	**HR**	**REC**	**DV(Total)**	**DV(BKG)**	**DELTA DV**	**f(RH)**	**%_SO4**	**%_NO3**	**%_OC**	**%_EC**	**%_PMC**	**%_PMF**	**Ranking**
2001	305	0	11	7.487	7.4	0.087	3.2	58.35	0	3.18	15.79	2.91	19.76	1
2001	343	0	1	7.459	7.4	0.058	3	57.09	0	3.32	16.48	2.49	20.62	2
2001	210	0	11	7.445	7.4	0.045	3.4	60.04	0	3.08	15.29	2.44	19.13	3
2001	204	0	11	7.445	7.4	0.045	3.4	60.47	0	3.11	15.4	1.74	19.27	4
2001	64	0	3	7.444	7.4	0.044	2.7	53.87	0	3.48	17.27	3.75	21.62	5
2001	215	0	3	7.442	7.4	0.042	3.7	62.38	0	2.94	14.6	1.8	18.27	6
2001	323	0	11	7.441	7.4	0.041	2.8	55.79	0	3.48	17.25	1.88	21.59	7
2001	347	0	40	7.434	7.4	0.034	3	56.39	0	3.28	16.28	3.68	20.37	8
2001	247	0	40	7.433	7.4	0.033	3.6	61.88	0	3	14.88	1.61	18.62	9
2001	44	0	11	7.431	7.4	0.031	2.6	53.65	0	3.6	17.87	2.52	22.36	10
2001	178	0	47	7.426	7.4	0.026	3.3	60.02	0	3.18	15.75	1.34	19.71	11
2001	205	0	52	7.425	7.4	0.025	3.4	60.72	0	3.12	15.46	1.35	19.35	12
2001	72	0	3	7.425	7.4	0.025	2.7	55.19	0	3.57	17.7	1.38	22.15	13
2001	166	0	3	7.425	7.4	0.024	3.3	58.99	0	3.12	15.48	3.04	19.37	14
2001	165	0	3	7.422	7.4	0.022	3.3	60.13	0	3.18	15.78	1.16	19.74	15
2001	54	0	11	7.422	7.4	0.022	2.6	54.05	0	3.63	18	1.78	22.53	16
2001	216	0	40	7.422	7.4	0.021	3.7	62.71	0	2.96	14.68	1.28	18.36	17
2001	128	0	3	7.417	7.4	0.017	3	58.21	0	3.39	16.8	0.57	21.02	18
2001	56	0	1	7.416	7.4	0.016	2.6	54.5	0	3.66	18.15	0.97	22.71	19
2001	141	0	47	7.416	7.4	0.015	3	57.4	0	3.34	16.57	1.94	20.73	20
2002	283	0	3	7.544	7.4	0.144	3.2	58.45	0	3.19	15.82	2.75	19.79	1
2002	252	0	3	7.52	7.4	0.12	3.6	61.9	0	3	14.89	1.58	18.63	2
2002	174	0	11	7.503	7.4	0.103	3.3	59.37	0	3.14	15.58	2.42	19.49	3
2002	173	0	3	7.465	7.4	0.065	3.3	58.68	0	3.11	15.4	3.55	19.27	4
2002	284	0	50	7.458	7.4	0.058	3.2	58.63	0	3.2	15.87	2.44	19.85	5
2002	234	0	1	7.45	7.4	0.05	3.7	62.35	0	2.94	14.59	1.85	18.26	6
2002	353	0	3	7.445	7.4	0.044	3	57.83	0	3.37	16.69	1.22	20.89	7
2002	172	0	40	7.433	7.4	0.033	3.3	59.62	0	3.16	15.64	2	19.58	8
2002	299	0	1	7.432	7.4	0.031	3.2	58.2	0	3.18	15.75	3.16	19.71	9
2002	86	0	47	7.431	7.4	0.031	2.7	55.13	0	3.57	17.68	1.49	22.12	10
2002	183	0	11	7.426	7.4	0.026	3.4	60.64	0	3.11	15.44	1.48	19.32	11
2002	102	0	47	7.425	7.4	0.024	2.4	52.52	0	3.82	18.95	0.99	23.71	12
2002	298	0	10	7.422	7.4	0.022	3.2	58.25	0	3.18	15.76	3.08	19.72	13
2002	274	0	11	7.423	7.4	0.022	3.6	61.84	0	3	14.87	1.66	18.61	14
2002	346	0	1	7.422	7.4	0.021	3	56.33	0	3.28	16.26	3.79	20.34	15
2002	203	0	11	7.42	7.4	0.019	3.4	61.04	0	3.14	15.55	0.81	19.45	16
2002	20	0	3	7.419	7.4	0.019	2.8	54.6	0	3.41	16.89	3.96	21.13	17
2002	112	0	40	7.419	7.4	0.018	2.4	52.7	0	3.83	19.01	0.66	23.79	18
2002	216	0	3	7.417	7.4	0.017	3.7	62.02	0	2.93	14.51	2.35	18.16	19
2002	80	0	30	7.416	7.4	0.016	2.7	55.16	0	3.57	17.69	1.46	22.13	20
2003	323	0	11	7.541	7.4	0.141	2.8	54.46	0	3.4	16.84	4.23	21.07	1
2003	141	0	11	7.514	7.4	0.114	3	56.37	0	3.28	16.27	3.71	20.36	2
2003	339	0	11	7.469	7.4	0.069	3	56.38	0	3.28	16.27	3.7	20.36	3
2003	169	0	40	7.459	7.4	0.059	3.3	59.62	0	3.16	15.64	2.01	19.57	4
2003	283	0	10	7.435	7.4	0.034	3.2	58.84	0	3.21	15.92	2.1	19.92	5
2003	144	0	3	7.429	7.4	0.029	3	57.41	0	3.34	16.57	1.93	20.74	6
2003	126	0	11	7.425	7.4	0.025	3	57.75	0	3.36	16.67	1.36	20.86	7
2003	308	0	11	7.421	7.4	0.021	2.8	55.95	0	3.49	17.3	1.6	21.65	8
2003	265	0	10	7.422	7.4	0.021	3.6	62.21	0	3.02	14.96	1.07	18.72	9
2003	75	0	11	7.42	7.4	0.019	2.7	55.38	0	3.58	17.76	1.05	22.22	10
2003	147	0	47	7.418	7.4	0.018	3	57.99	0	3.38	16.74	0.94	20.95	11
2003	125	0	1	7.418	7.4	0.018	3	57.31	0	3.34	16.54	2.1	20.7	12
2003	145	0	3	7.417	7.4	0.017	3	57.71	0	3.36	16.66	1.41	20.84	13
2003	4	0	47	7.417	7.4	0.017	2.8	56.24	0	3.51	17.39	1.09	21.76	14
2003	257	0	10	7.414	7.4	0.013	3.6	60.45	0	2.93	14.54	3.86	18.2	15
2003	98	0	3	7.413	7.4	0.013	2.4	51.52	0	3.75	18.59	2.86	23.26	16
2003	328	0	47	7.412	7.4	0.012	2.8	56.12	0	3.5	17.35	1.29	21.72	17
2003	232	0	40	7.409	7.4	0.009	3.7	62.05	0	2.93	14.52	2.3	18.17	18
2003	78	0	3	7.41	7.4	0.009	2.7	54.41	0	3.52	17.45	2.76	21.83	19
2003	281	0	47	7.408	7.4	0.008	3.2	58.28	0	3.18	15.77	3	19.73	20

Ranked Daily Visibility Change for Swanquarter (Top 20 Days for Each Year)

								% of Modeled Extinction by Species						
YEAR	DAY	HR	REC	DV(Total)	DV(BKG)	DELTA DV	f(RH)	%_SO4	%_NO3	%_OC	%_EC	%_PMC	%_PMF	Ranking
2001	357	0	388	7.53	7.381	0.149	2.9	56.03	0	3.37	16.73	2.94	20.93	1
2001	272	0	388	7.528	7.381	0.147	3.4	60.1	0	3.09	15.31	2.36	19.15	2
2001	311	0	392	7.486	7.381	0.105	2.8	55.37	0	3.45	17.12	2.64	21.42	3
2001	361	0	397	7.473	7.381	0.092	2.9	56.38	0	3.4	16.83	2.32	21.07	4
2001	256	0	353	7.47	7.381	0.089	3.4	59.19	0	3.04	15.07	3.83	18.86	5
2001	282	0	388	7.468	7.381	0.087	3.1	57.68	0	3.25	16.11	2.8	20.16	6
2001	169	0	364	7.469	7.381	0.087	3.2	59.32	0	3.24	16.05	1.31	20.09	7
2001	310	0	398	7.468	7.381	0.086	2.8	55.28	0	3.45	17.1	2.79	21.39	8
2001	236	0	388	7.459	7.381	0.078	3.5	60.89	0	3.04	15.06	2.17	18.85	9
2001	191	0	402	7.457	7.381	0.076	3.4	60.27	0	3.1	15.35	2.08	19.21	10
2001	170	0	367	7.456	7.381	0.075	3.2	58.04	0	3.17	15.7	3.44	19.65	11
2001	273	0	364	7.455	7.381	0.073	3.4	59.65	0	3.06	15.19	3.08	19.01	12
2001	303	0	388	7.453	7.381	0.072	3.1	57.82	0	3.26	16.15	2.57	20.21	13
2001	289	0	401	7.449	7.381	0.068	3.1	57.74	0	3.25	16.13	2.7	20.18	14
2001	27	0	388	7.448	7.381	0.067	2.9	56.04	0	3.37	16.73	2.92	20.94	15
2001	35	0	364	7.444	7.381	0.063	2.7	54.22	0	3.51	17.39	3.12	21.76	16
2001	135	0	377	7.442	7.381	0.061	2.9	55.67	0	3.35	16.62	3.55	20.8	17
2001	281	0	388	7.441	7.381	0.06	3.1	57.66	0	3.25	16.11	2.83	20.15	18
2001	160	0	388	7.44	7.381	0.059	3.2	58.18	0	3.18	15.74	3.21	19.7	19
2001	197	0	364	7.436	7.381	0.055	3.4	59.26	0	3.04	15.09	3.73	18.88	20
2002	333	0	367	7.546	7.381	0.165	2.8	55.04	0	3.43	17.02	3.21	21.3	1
2002	261	0	388	7.544	7.381	0.163	3.4	59.81	0	3.07	15.23	2.82	19.06	2
2002	40	0	364	7.511	7.381	0.13	2.7	54.13	0	3.5	17.36	3.29	21.72	3
2002	286	0	402	7.502	7.381	0.12	3.1	57.43	0	3.24	16.04	3.22	20.07	4
2002	319	0	397	7.495	7.381	0.114	2.8	55	0	3.43	17.01	3.28	21.28	5
2002	341	0	364	7.49	7.381	0.109	2.9	55.94	0	3.37	16.7	3.09	20.9	6
2002	88	0	388	7.487	7.381	0.106	2.6	53.3	0	3.58	17.75	3.16	22.21	7
2002	97	0	364	7.487	7.381	0.105	2.5	52.41	0	3.66	18.15	3.07	22.71	8
2002	342	0	364	7.482	7.381	0.101	2.9	55.74	0	3.36	16.64	3.44	20.83	9
2002	287	0	352	7.479	7.381	0.097	3.1	57.01	0	3.21	15.92	3.93	19.93	10
2002	3	0	398	7.469	7.381	0.088	2.9	56.17	0	3.38	16.77	2.69	20.99	11
2002	115	0	388	7.466	7.381	0.085	2.5	52.43	0	3.66	18.16	3.04	22.72	12
2002	64	0	388	7.46	7.381	0.078	2.6	53.41	0	3.59	17.79	2.96	22.26	13
2002	50	0	398	7.455	7.381	0.073	2.7	54.63	0	3.53	17.52	2.39	21.92	14
2002	267	0	397	7.45	7.381	0.069	3.4	59.77	0	3.07	15.22	2.9	19.05	15
2002	199	0	397	7.446	7.381	0.065	3.4	59.58	0	3.06	15.17	3.21	18.99	16
2002	301	0	388	7.446	7.381	0.064	3.1	56.81	0	3.2	15.87	4.28	19.85	17
2002	292	0	398	7.443	7.381	0.062	3.1	57.63	0	3.25	16.1	2.89	20.14	18
2002	17	0	388	7.443	7.381	0.062	2.9	55.79	0	3.36	16.66	3.35	20.85	19
2002	291	0	364	7.442	7.381	0.061	3.1	57.43	0	3.24	16.04	3.23	20.07	20
2003	298	0	388	7.523	7.381	0.141	3.1	57.66	0	3.25	16.1	2.84	20.15	1
2003	343	0	364	7.499	7.381	0.117	2.9	55.78	0	3.36	16.66	3.37	20.84	2
2003	276	0	377	7.493	7.381	0.111	3.1	57.83	0	3.26	16.15	2.54	20.21	3
2003	356	0	389	7.488	7.381	0.107	2.9	55.78	0	3.36	16.66	3.36	20.84	4
2003	173	0	364	7.474	7.381	0.093	3.2	58.3	0	3.18	15.78	3	19.74	5
2003	23	0	402	7.471	7.381	0.09	2.9	56.29	0	3.39	16.81	2.49	21.03	6
2003	154	0	388	7.469	7.381	0.088	3.2	58.3	0	3.18	15.78	3	19.74	7
2003	119	0	397	7.468	7.381	0.087	2.5	53.18	0	3.72	18.42	1.64	23.05	8
2003	273	0	389	7.461	7.381	0.08	3.4	59.63	0	3.06	15.19	3.12	19	9
2003	68	0	402	7.451	7.381	0.07	2.6	53.25	0	3.58	17.73	3.25	22.19	10
2003	114	0	389	7.448	7.381	0.067	2.5	52.71	0	3.68	18.26	2.51	22.84	11
2003	260	0	388	7.445	7.381	0.064	3.4	59.45	0	3.05	15.14	3.41	18.95	12
2003	115	0	388	7.445	7.381	0.064	2.5	52.17	0	3.64	18.07	3.5	22.61	13
2003	19	0	402	7.441	7.381	0.059	2.9	55.79	0	3.36	16.66	3.36	20.84	14
2003	105	0	388	7.436	7.381	0.055	2.5	52.95	0	3.7	18.34	2.06	22.95	15
2003	297	0	398	7.432	7.381	0.05	3.1	57.9	0	3.26	16.17	2.42	20.24	16
2003	85	0	388	7.429	7.381	0.048	2.6	53.35	0	3.58	17.77	3.08	22.23	17
2003	61	0	397	7.43	7.381	0.048	2.6	53.18	0	3.57	17.71	3.38	22.16	18
2003	176	0	364	7.428	7.381	0.047	3.2	58.48	0	3.19	15.82	2.71	19.8	19
2003	296	0	364	7.425	7.381	0.044	3.1	57.61	0	3.25	16.09	2.92	20.13	20

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